

## Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 43  
September 2010

### Acoustic Travel-Time Tomography

*A new cost effective and non-destructive method for improved assessment of mass concrete dams*

#### What Is The Problem?

Many of the large concrete dams in the United States and globally have reached or passed their design life. Therefore, increased monitoring of the surface and the internal structure of these dams is needed to ensure their safe operation. Structural monitoring often includes destructive testing methods such as drilling and coring—extracting small pieces from the dam to analyze its internal structure. Drilling and coring costs are relatively high and the data collected can be of limited value. Depending on the number and the locations of the cores taken, there can be limited confidence extrapolating the data to represent the entire structure. Thus, a more cost effective method is needed to evaluate the structural adequacy of large concrete dams.

#### What Is The Solution?

Reclamation's Materials Engineering and Research Laboratory has developed a non-destructive, affordable, and accurate method for analysis of large concrete structures called Acoustic Travel-Time Tomography (ATTT). ATTT combines aspects of ultrasonic measurements for materials characterization and shallow seismic surveys.

ATTT uses an array of acoustic sensors placed in vertical lines on the upstream and downstream faces of the dam. The sensors are used to measure the sound wave travel time between the acoustic source and each respective sensor. Data are collected with the acoustic source located at various points on the top of the dam. Source and receiver locations are documented using conventional surveying techniques. The data are entered into a the three-dimensional tomography (3DTOM) tomographic software developed by the Bureau of Mines, which maps the sound wave velocities into cross-sectional images used to locate any cracks, voids, structural damage, and other anomalies deep inside the structure.



Installing acoustic sensors on the downstream face of Barker Dam.

#### Who Can Benefit?

Owners of large concrete dams can benefit from the application of ATTT to cost-effectively evaluate structural conditions. ATTT can be used in combination with other testing methods to analyze potential problems and determine the need and extent of remediation measures.

#### Where Have We Applied This Solution?

A pilot study employing ATTT was conducted by Reclamation staff at Barker Dam near Boulder, Colorado in 1998. The results of the study indicate ATTT successfully identified cracks and other anomalies in the dam. ATTT's primary application is to assess large concrete dams for determining cracks, airpockets, or weak areas. ATTT can also be used to assess other large concrete structures such as buildings, bridges, roadways, airstrips, piers, and locks.

#### Future Development Plans

Further research into the application of ATTT is being conducted to develop improved correlations between acoustic wave velocities and concrete strength-related characteristics within a dam. Also, the use of laser technology is being evaluated as an alternative to placing sensors on the face of the dam where data can be collected from an unlimited number of locations. This could significantly lower the installation cost of ATTT and make it a safer method.

#### More Information

Patents are available for commercial licensing. Please see Patent numbers [U.S. 6,105,430](#) *Inspection of Concrete Structures Using Sonic Tomography*, Kepler and Bond. Granted 8/2000. A nondestructive testing procedure for finding cracks and voids in large concrete dams and [U.S. 6,823,73](#) *Detector for Buried Pipelines and Conduits Using Acoustic Resonance*. Kepler and Travers. Granted 5/2002. A nondestructive testing procedure for finding voids behind buried pipelines.

#### Contact Information

Bill Kepler, Materials Engineering and Research Laboratory  
303-445-2386, [wkepler@usbr.gov](mailto:wkepler@usbr.gov)

#### Collaborators

Reclamation Science and Technology Program, Colorado State University, and Pacific Northwest National Laboratory